



2-Ch RAID0 (NVMe-IP for Gen5) Demo Instruction

Rev1.0 28-Jun-23

1	Overview	2
2	Test Menu.....	3
2.1	Identify Command.....	3
2.2	Write Command.....	4
2.3	Read Command.....	6
2.4	SMART Command.....	8
2.5	Flush Command	9
2.6	Secure Erase Command	9
2.7	Shutdown Command	10
3	Revision History	11

1 Overview

This document describes the instruction to run 2-ch RAID0 demo using NVMe-IP for Gen5. The demo is run on FPGA development board to access two NVMe Gen5 SSDs in a RAID0 configuration. There are seven test menus for executing each command - Identify, Write, Read, SMART, Flush, Secure Erase, and Shutdown. The user can control the test operations through FPGA console.

Before proceeding with the demo, please ensure that the FPGA board has been completely setup according to the “dg_nvmeip_fpgasetup_g5_intel” document, which can be found at the following link.

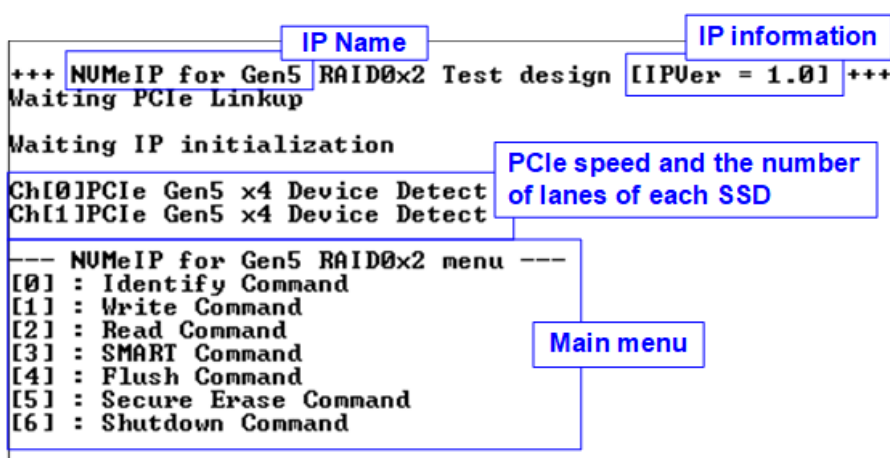
https://dgway.com/products/IP/NVMe-IP/dg_nvmeip_fpgasetup_g5_intel_en/

```

+++ NUmEIP for Gen5 RAID0x2 Test design [IPVer = 1.0] +++
Waiting PCIe Linkup

Waiting IP initialization
Ch[0]PCIe Gen5 x4 Device Detect
Ch[1]PCIe Gen5 x4 Device Detect

--- NUmEIP for Gen5 RAID0x2 menu ---
[0] : Identify Command
[1] : Write Command
[2] : Read Command
[3] : SMART Command
[4] : Flush Command
[5] : Secure Erase Command
[6] : Shutdown Command
  
```



The diagram shows a terminal window with the following text and callouts:

- IP Name**: Points to "NUMeIP for Gen5 RAID0x2 Test design"
- IP information**: Points to "[IPVer = 1.0]"
- PCIe speed and the number of lanes of each SSD**: Points to "Ch[0]PCIe Gen5 x4 Device Detect" and "Ch[1]PCIe Gen5 x4 Device Detect"
- Main menu**: Points to the menu list starting with "--- NUmEIP for Gen5 RAID0x2 menu ---"

Figure 1-1 2-Ch NVMe-IP (Gen5) RAID0 demo main menu

On welcome screen, the IP name and version number are displayed. The next message provides the information about the PCIe speed and the number of PCIe lanes of each channel. Finally, the test menu is displayed on the console.

2 Test Menu

2.1 Identify Command

The Identify command is used to retrieve information about the NVMe SSD. To send the Identify command, select '0' from the console menu. Once the command operation is completed, the console displays the following three pieces of information.

```

+++ Identify Command selected +++
Ch[0]Model Number : CSSD-M2M2TPG5NFZ
Ch[1]Model Number : GIGABYTE AG510K2TB
RAID Capacity= 4000[GB]
Secure Erase Command : Support

--- NUMeIP for Gen5 RAID0x2 menu
[0] : Identify Command
[1] : Write Command
[2] : Read Command
[3] : SMART Command
[4] : Flush Command
[5] : Secure Erase Command
[6] : Shutdown Command
  
```

Model name, RAID0 capacity,
and Secure Erase Command Support

Figure 2-1 Test result when running Identify command

- 1) SSD model number : This value is decoded from Identify controller data of each SSD.
- 2) RAID capacity : This value is determined by multiplying SSD capacity in channel#0 by 2. Therefore, it is recommended to connect two SSDs for RAID0.
Note: If the connected SSDs have different capacities, it is recommended to connect the SSD with smaller capacity to Ch#0.
- 3) Secure Erase Command Support: This value is decoded from the Identify controller data to show whether the SSD supports the Secure Erase command.

The RAID0 design supports only the SSD LBA Size of 512 bytes. If the connected SSDs use different LBA Size values, a warning message shown in Figure 2-2 will be displayed. In such cases, RAID0 controller hardware in HDL code must be modified.

```

Unsupported LBA size is detected
Warning : LBA Size Not Support!
Please Check Devices
  
```

Figure 2-2 Error message when LBA size does not support

2.2 Write Command

The Write command is used to write data to the RAID0. To execute the Write command, select '1' from the test menu.

```

+++ Write Command selected +++
Enter Start Address (512 Byte)      : 0 - 0x00000001D1C1115F => 0
Enter Length (512 Byte)            : 1 - 0x00000001D1C11160 => 0x20000000
Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR => 4
20.366 [GB]
40.868 [GB]
60.919 [GB]
|
223.906 [GB]
243.821 [GB]
263.871 [GB]
Total = 274.877 [GB] , Time = 13550[ms] , Transfer speed = 20285[MB/s]

--- NUMeIP for Gen5 RAID0x2 menu ---
[0] : Identify Command
[1] : Write Command
[2] : Read Command
[3] : SMART Command
[4] : Flush Command
[5] : Secure Erase Command
[6] : Shutdown Command

```

Figure 2-3 Input and Test result when running Write command

The user needs to input three parameters.

- 1) Start Address: Specifies the start address to write the RAID0 as a 512-byte unit. The input is in decimal unit when the user inputs only digits. The user can add “0x” as a prefix for hexadecimal units.
- 2) Transfer Length: Specifies the total transfer size as a 512-byte unit. The input is in decimal unit when the user inputs only digits. The user can add “0x” as a prefix for hexadecimal units.
- 3) Test pattern: Used to select the test data pattern for writing to the RAID0. The user can choose from five patterns, including 32-bit incremental, 32-bit decremental, all 0, all 1, and 32-bit LFSR counter.

Once all input parameters are validated, the write operation begins. The console displays the current amount of written data every second to indicate that the system is still running. Upon completion, the console shows the total size of data, time usage, and test speed as the test results.

Note:

1. The performance of RAID0x2 is approximately twice that of a single SSD. To achieve optimal performance, it is recommended to use the same SSD model for all SSD channels. However, if different SSD models are used in the system, the RAID0x2 performance is limited to two times of the performance of slower SSD.
2. The write performance of SSDs may decrease after long data transfer. In some cases, the performance can be restored by executing the Secure Erase command.



← 64-bit header of 512-byte data →																																	
48-bit LBA Address = 0								32-bit Increment pattern								48-bit LBA Address = 1																	
Offset	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	Offset	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
00000000	00	00	00	00	00	00	00	00	02	00	00	00	03	00	00	00	00000000	01	00	00	00	00	00	00	00	82	00	00	00	83	00	00	00
00000010	04	00	00	00	05	00	00	00	06	00	00	00	07	00	00	00	00000010	84	00	00	00	85	00	00	00	86	00	00	00	87	00	00	00
00000020	08	00	00	00	09	00	00	00	0A	00	00	00	0B	00	00	00	00000020	88	00	00	00	89	00	00	00	8A	00	00	00	8B	00	00	00
00000030	0C	00	00	00	0D	00	00	00	0E	00	00	00	0F	00	00	00	00000030	8C	00	00	00	8D	00	00	00	8E	00	00	00	8F	00	00	00
00000040	10	00	00	00	11	00	00	00	12	00	00	00	13	00	00	00	00000040	90	00	00	00	91	00	00	00	92	00	00	00	93	00	00	00
00000050	14	00	00	00	15	00	00	00	16	00	00	00	17	00	00	00	00000050	94	00	00	00	95	00	00	00	96	00	00	00	97	00	00	00
SSD#0																SSD#1																	
000001B0	6C	00	00	00	6D	00	00	00	6D	00	00	00	6F	00	00	00	000001B0	EC	00	00	00	ED	00	00	00	ED	00	00	00	EF	00	00	00
000001C0	70	00	00	00	71	00	00	00	72	00	00	00	73	00	00	00	000001C0	F0	00	00	00	F1	00	00	00	F2	00	00	00	F3	00	00	00
000001D0	74	00	00	00	75	00	00	00	76	00	00	00	77	00	00	00	000001D0	F4	00	00	00	F5	00	00	00	F6	00	00	00	F7	00	00	00
000001E0	78	00	00	00	79	00	00	00	7A	00	00	00	7B	00	00	00	000001E0	F8	00	00	00	F9	00	00	00	FA	00	00	00	FB	00	00	00
000001F0	7C	00	00	00	7D	00	00	00	7D	00	00	00	7F	00	00	00	000001F0	FC	00	00	00	FD	00	00	00	FD	00	00	00	FF	00	00	00
00000200	02	00	00	00	00	00	00	00	02	01	00	00	03	01	00	00	00000200	03	00	00	00	00	00	00	00	82	01	00	00	83	01	00	00
00000210	04	01	00	00	05	01	00	00	06	01	00	00	07	01	00	00	00000210	84	01	00	00	85	01	00	00	86	01	00	00	87	01	00	00
00000220	08	01	00	00	09	01	00	00	0A	01	00	00	0B	01	00	00	00000220	88	01	00	00	89	01	00	00	8A	01	00	00	8B	01	00	00

64-bit header of the next 512-byte data

Figure 2-4 Example Test data of the 1st 512-byte of each SSD by using incremental pattern

In the 2-ch RAID0 dem, the stripe size of RAID0 is set to 512 bytes. When using incremental, decremental, and LFSR pattern, each 512-byte data block has a unique 64-bit header which consists of a 48-bit address (in 512-byte unit) and a 16-bit zero value. Following the header, the data block contains the test pattern selected by the user. When using all-0 or all-1 pattern, the unique 64-bit header is not included.

In the RAID0 configuration, the first stripe is mapped to the first 512-byte of SSD#0, while the second stripe of RAID0 is mapped to the first 512-byte of SSD#1, as shown in Figure 2-4.

```

Error input
+++ Write Command selected +++
Enter Start Address (512 Byte) : 0 - 0x00000001D1C1115F => 0x1FFFFFFFF
Invalid input Out of range address

+++ Write Command selected +++
Enter Start Address (512 Byte) : 0 - 0x00000001D1C1115F => 0
Enter Length (512 Byte) : 1 - 0x00000001D1C11160 => 0x1FFFFFFFF
Invalid input Out of range length

+++ Write Command selected +++
Enter Start Address (512 Byte) : 0 - 0x00000001D1C1115F => 0
Enter Length (512 Byte) : 1 - 0x00000001D1C11160 => 0x20000000
Selected Pattern [0]Inc32 [1]Dec32 [2]A11_0 [3]A11_1 [4]LFSR => 5
Invalid input Invalid pattern
    
```

Figure 2-5 Error message from the invalid input

Figure 2-5 shows an example when the input is out-of-range from the recommended range for each parameter. The console displays “Invalid input”, and then the operation is cancelled.

2.3 Read Command

The Read command is used to read data from the RAID0. To execute the Read command, select '2' from the test menu.

```

+++ Read Command selected +++
Enter Start Address <512 Byte>      : 0 - 0x00000001D1C1115F => 0
Enter Length <512 Byte>             : 1 - 0x00000001D1C11160 => 0x20000000
Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LFSR => 4
16.951 [GB]
33.907 [GB]
50.865 [GB]
|
237.416 [GB]
254.374 [GB]
271.331 [GB]
|
Total = 274.877 [GB] , Time = 16209[ms] , Transfer speed = 16957[MB/s]

--- NUMeIP for Gen5 RAID0x2 menu ---
[0] : Identify Command
[1] : Write Command
[2] : Read Command
[3] : SMART Command
[4] : Flush Command
[5] : Secure Erase Command
[6] : Shutdown Command

```

Figure 2-6 Input and result of Read Command menu

The user needs to input three parameters.

- 1) Start Address: Specifies the start address to read the RAID0 as a 512-byte unit. The input is in decimal unit when the user inputs only digits. The user can add "0x" as a prefix for hexadecimal units.
- 2) Transfer Length: Specifies the total transfer size as a 512-byte unit. The input is in decimal unit when the user inputs only digits. The user can add "0x" as a prefix for hexadecimal units.
- 3) Test pattern: Used to select the test data pattern for reading and verifying data from the RAID0. The test pattern must match the one used in the Write command menu. There are five available patterns: 32-bit incremental, 32-bit decremental, all 0, all 1, and 32-bit LFSR counter.

If all inputs are valid, the test system reads data from the RAID0. While the operation is in progress, the console displays the current amount of read data every second to indicate that the system is still running. When the operation is complete, the console shows the total size of data, time usage, and test speed.

Note:

1. The performance of RAID0x2 is approximately twice that of a single SSD. To achieve optimal performance, it is recommended to use the same SSD model for all SSD channels. However, if different SSD models are used in the system, the RAID0x2 performance is limited to two times of the performance of slower SSD.
2. It is found that some SSDs shows varying performance characteristic when different test patterns are utilized. For instance, the read performance is better when using all-zero pattern compared to using an LFSR pattern.

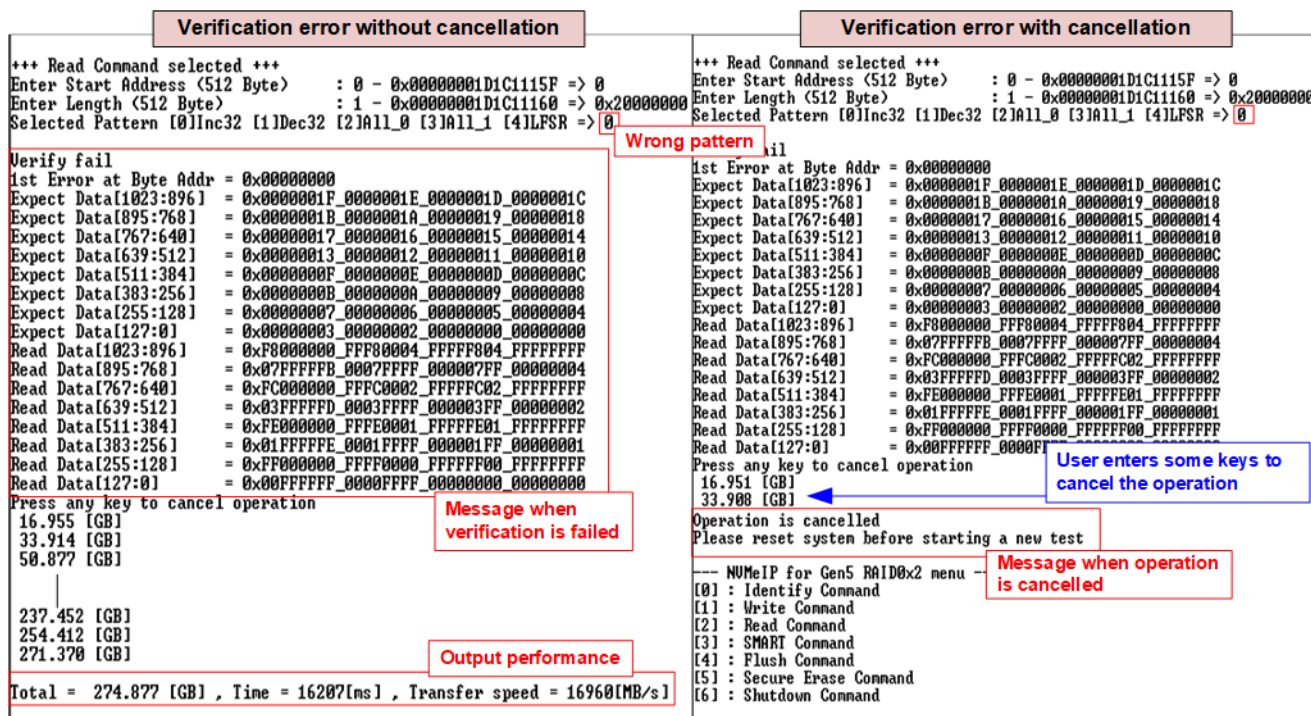


Figure 2-7 Data verification is failed

In case of a failed data verification during Read command, an error message is displayed on the console, as shown in Figure 2-7. The message “Verify fail” is displayed with information about the first failure data, such as the error byte address, the expected value, and the read value.

To cancel the Read operation, the user can press any key(s). However, if the operation is not cancelled, it will continue running until it finishes. Once it has finished, the output performance is displayed on the console.

Though the operation is cancelled, the Read command continues running as a background process and may not finish in a proper sequence. Therefore, it is recommended to power off and then power on both the FPGA board and adapter board (if connected) after cancelling the operation.

2.4 SMART Command

Select '3' to send a SMART command to the RAID0. After the operation is complete, the console will display the SMART/Health Information output (see Figure 2-8). This information includes both the Health status and SMART log information.

```

+++ SMART Command selected +++
++ ch[0]
<< Health Status >>
Remaining Life : 89%
<< SMART Log Information Ch[0] >>
Percentage Used : 11%
Temperature : 33 Degree Celsius
Total Data Read : 133295 GB
Total Data Read <Raw data> : 0x00000000_00000000_00000000_0F84438F
Total Data Written : 326532 GB
Total Data Written <Raw data> : 0x00000000_00000000_00000000_2602CF6F
Power On Cycles : 407 Times
Power On Hours : 93 Hours
Unsafe Shutdowns : 29 Times

++ ch[1]
<< Health Status >>
Remaining Life : 100%
<< SMART Log Information Ch[1] >>
Percentage Used : 0%
Temperature : 33 Degree Celsius
Total Data Read : 7237 GB
Total Data Read <Raw data> : 0x00000000_00000000_00000000_00D7ADF4
Total Data Written : 6788 GB
Total Data Written <Raw data> : 0x00000000_00000000_00000000_00CA4E9F
Power On Cycles : 9 Times
Power On Hours : 1 Hours
Unsafe Shutdowns : 2 Times

SMART Command Complete
  
```

Data output decoded from SMART command SSD#0

SSD#1

Figure 2-8 Test result when running SMART command

The Health status displays the remaining life of the SSD as a percentage, which is calculated from the Percentage Used value in the SMART log information. The SMART log information displays the following seven parameters.

- 1) Percentage used: The percentage of the SSD's lifespan that has been consumed.
- 2) Temperature: The temperature of the SSD in degree Celsius.
- 3) Total Data Read: The total amount of data that has been read from the SSD, displayed in GB/TB units. Additionally, the raw data without decoding is displayed as a 32-digit hex number (128 bits). The unit size of raw data is 512,000 bytes.
- 4) Total Data Written: The total amount of data that has been written to the SSD, displayed in GB/TB units. Additionally, the raw data without decoding is displayed as a 32-digit hex number (128 bits). The unit size of raw data is 512,000 bytes.
- 5) Power On Cycles: The number of times the SSD has been powered on.
- 6) Power On Hours: The total amount of time in hours that the SSD has been powered on.
- 7) Unsafe Shutdowns: The number of times the SSD has experienced an unsafe shutdown.

2.5 Flush Command

To initiate a Flush command on the RAID0, select option '4' from the menu. The Flush command ensures that all modified data in the cache memory is written to Flash memory in the SSD.

```

+++ Flush Command selected +++
Flush Command Complete
--- NUMeIP for Gen5 RA
[0] : Identify Command
[1] : Write Command
[2] : Read Command
[3] : SMART Command
[4] : Flush Command
[5] : Secure Erase Command
[6] : Shutdown Command
  
```

Figure 2-9 Test result when running Flush command

Once the Flush operation is completed, the console will display the message “Flush Command Complete”.

2.6 Secure Erase Command

Select option '5' to initiate a Secure Erase command to the RAID0. Before the operation starts, a confirmation message is displayed on the console, requesting the user to confirm the command. The user must enter 'y' or 'Y' to continue with the operation or any other key to cancel.

```

◆ : User input
◆ : User output

+++ Secure Erase Command selected +++
Are you sure to erase all Data ?
Press 'y' to confirm : y
Secure Erase Command Complete
--- NUMeIP for Gen5 RAID0x2
[0] : Identify Command
[1] : Write Command
[2] : Read Command
[3] : SMART Command
[4] : Flush Command
[5] : Secure Erase Command
[6] : Shutdown Command
  
```

Figure 2-10 Test result when running Secure Erase command

Once the Secure Erase command is completed, the console displays the message “Secure Erase Command Complete”.

2.7 Shutdown Command

Select '6' to send the Shutdown command to RAID0.

```

--- NUMeIP for Gen5 RAID0x2 menu ---
[0] : Identify Command
[1] : Write Command
[2] : Read Command
[3] : SMART Command
[4] : Flush Command
[5] : Secure Erase Command
[6] : Shutdown Command

+++ Shutdown Command selected +++
Are you sure you want to shutdown the device now ?
Press 'y' to confirm : y
Shutdown command is complete
The device has turned off...
  
```

◆ : User input
◆ : User output

Confirmation message

Press 'y' to confirm

Last message before RAID0 and all SSDs are inactive

Figure 2-11 Test result when running in Shutdown command

A confirmation message will be displayed on the console, and the user will need to enter 'y' or 'Y' to proceed with the operation. Press any other key to cancel the operation.

Once the Shutdown operation is complete, "Shutdown command is complete" will be displayed as the final message. The console becomes inactive. To begin a new test operation, the user will need to power off and on the test system.

3 Revision History

Revision	Date	Description
1.0	28-Jun-23	Initial version release